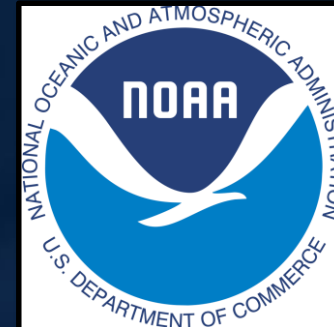


Short-term Forecasting Ground Magnetic Perturbations with the Space Weather Modeling Framework

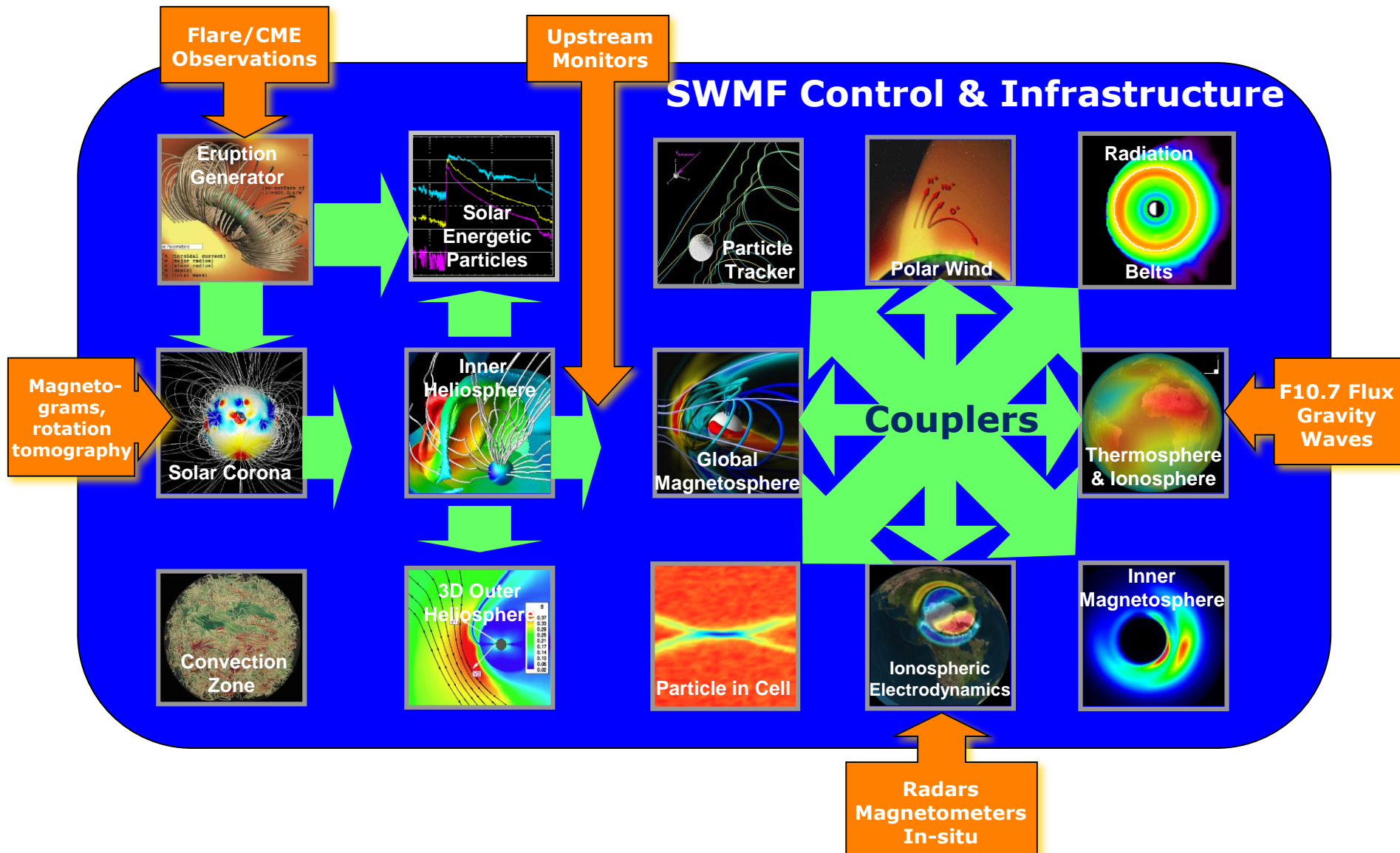
D. T. Welling¹, G. Toth¹, T. I. Gombosi¹,
H. Singer², G. Millward², C. Balch²

¹University of Michigan Center for Space Environment Modeling

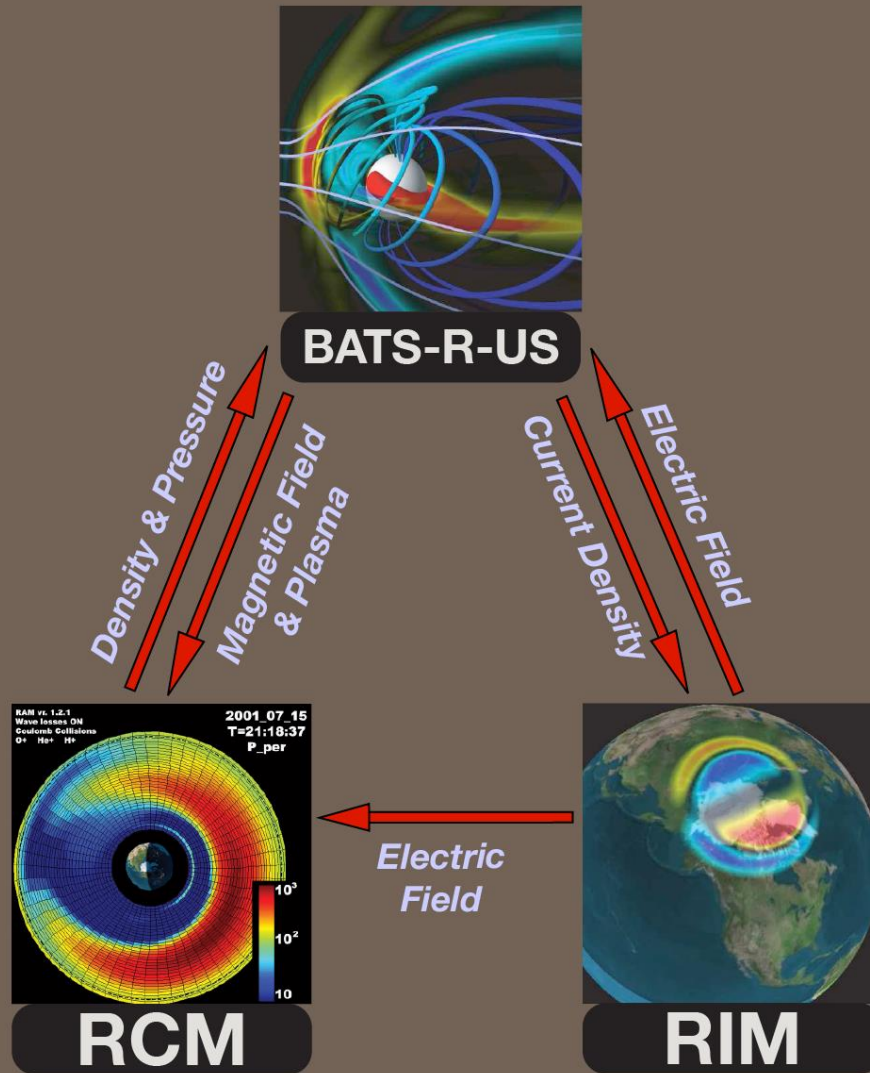
²NOAA Space Weather Prediction Center



Space Weather Modeling Framework



OPERATIONAL SWMF



Predictive

45 minute lead time with modest computer resources.

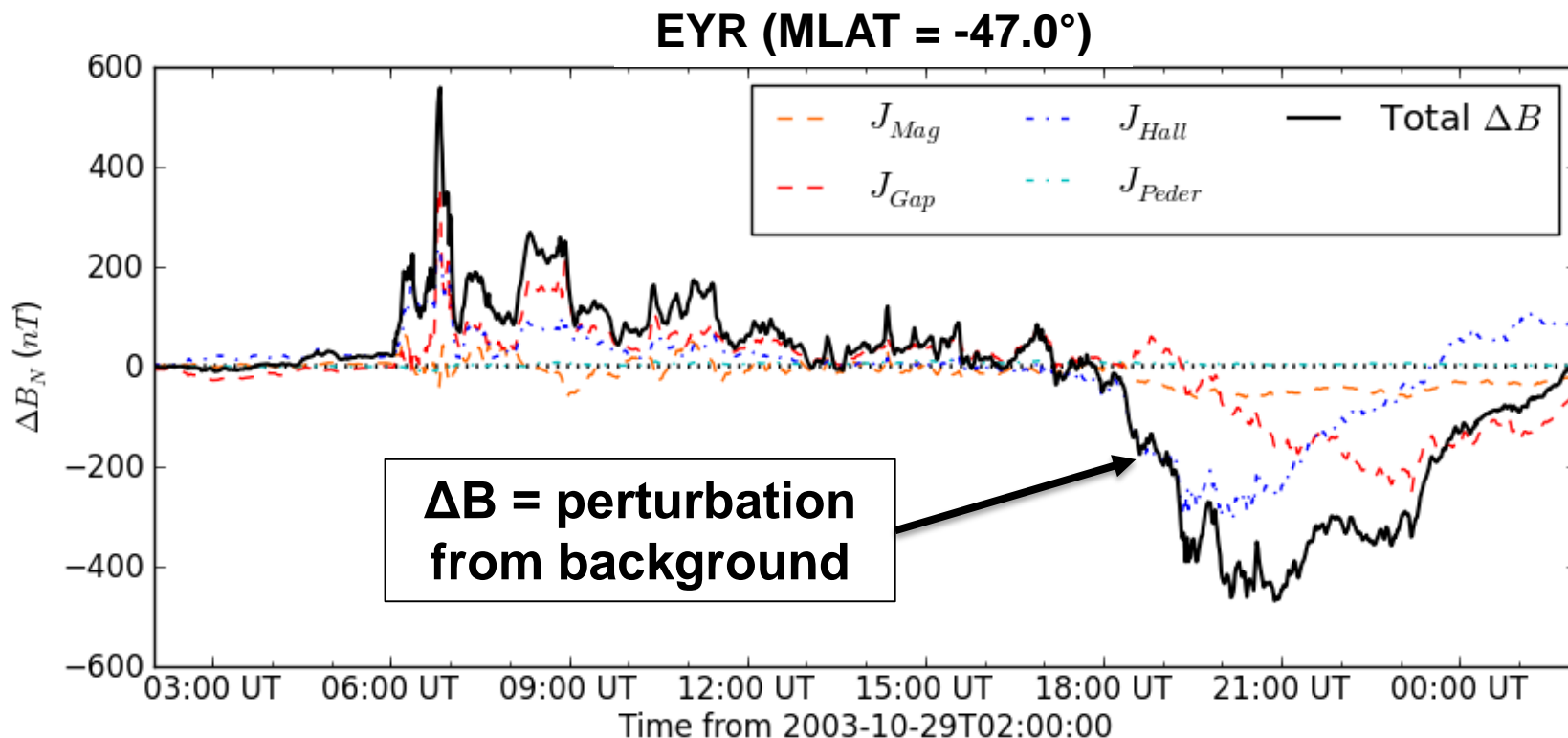
Robust

Can operate for prolonged periods without failure.

Relevant

Predicts ground dB/dt , spacecraft fluxes, magnetopause location, many more.

SWMF Virtual Magnetometers



Biot-Savart integral of *four* current systems

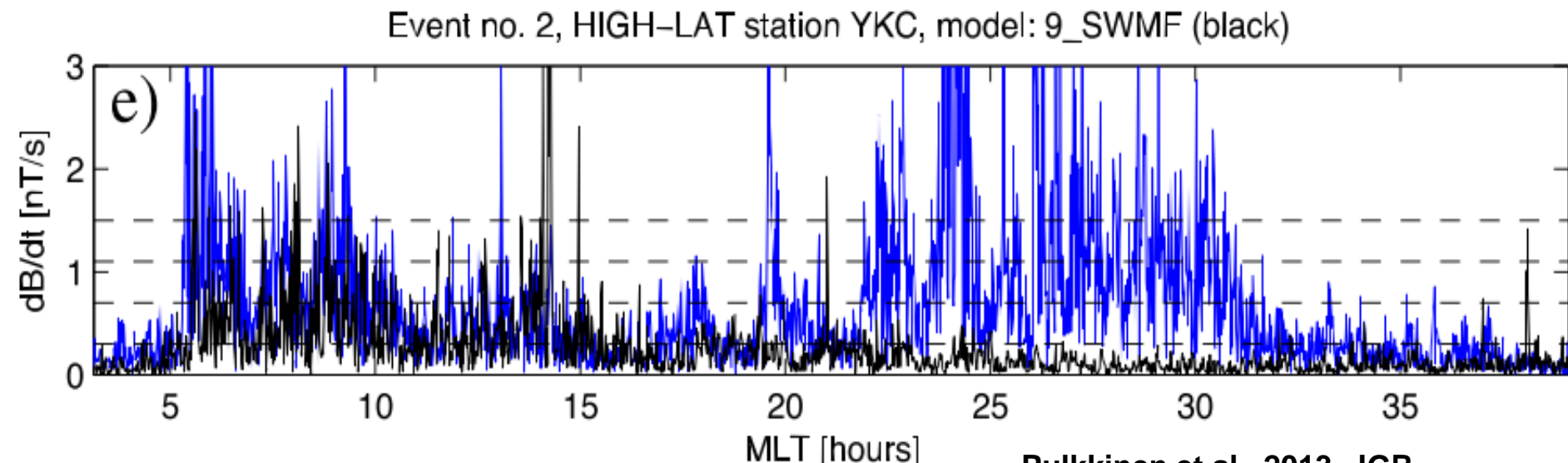
MHD: Global MHD & “gap region” currents

Ionosphere: Hall and Pedersen currents

Yu et al., 2010, JGR

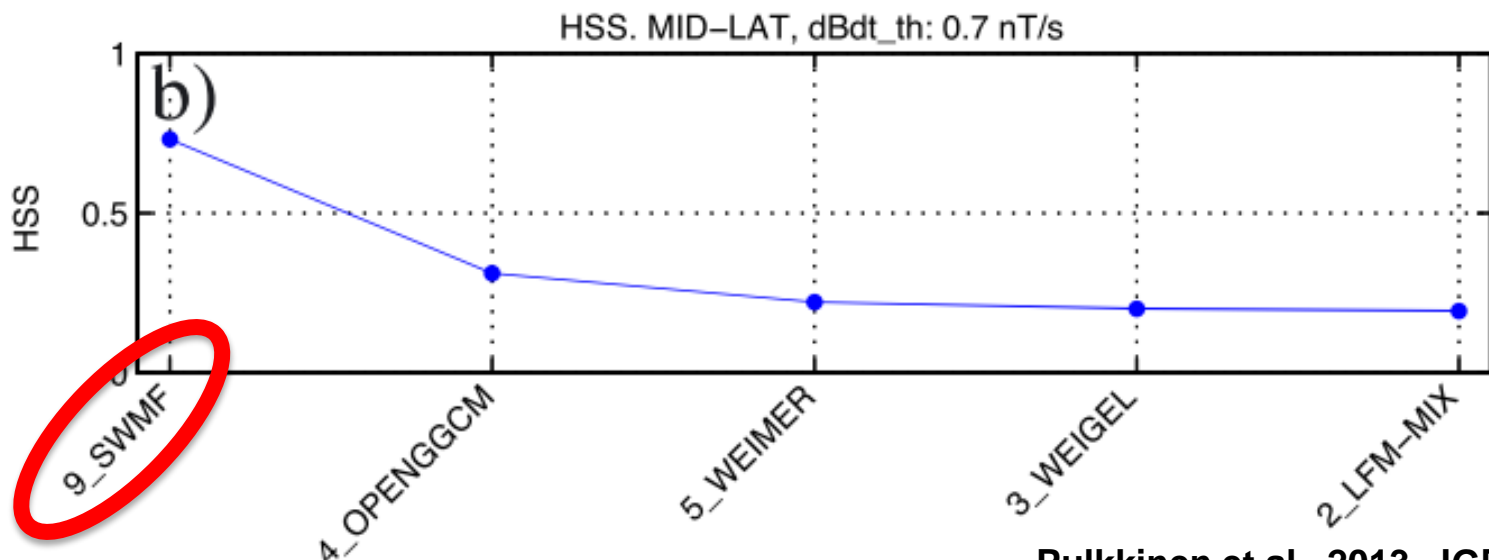
SWPC & NASA's CCMC teamed up to evaluate GIC predictive capabilities.

- 5 models evaluated for 6 storm events.
- Tested ability to predict ground $|dB/dt|$ from upstream solar conditions.
- Models run at CCMC.



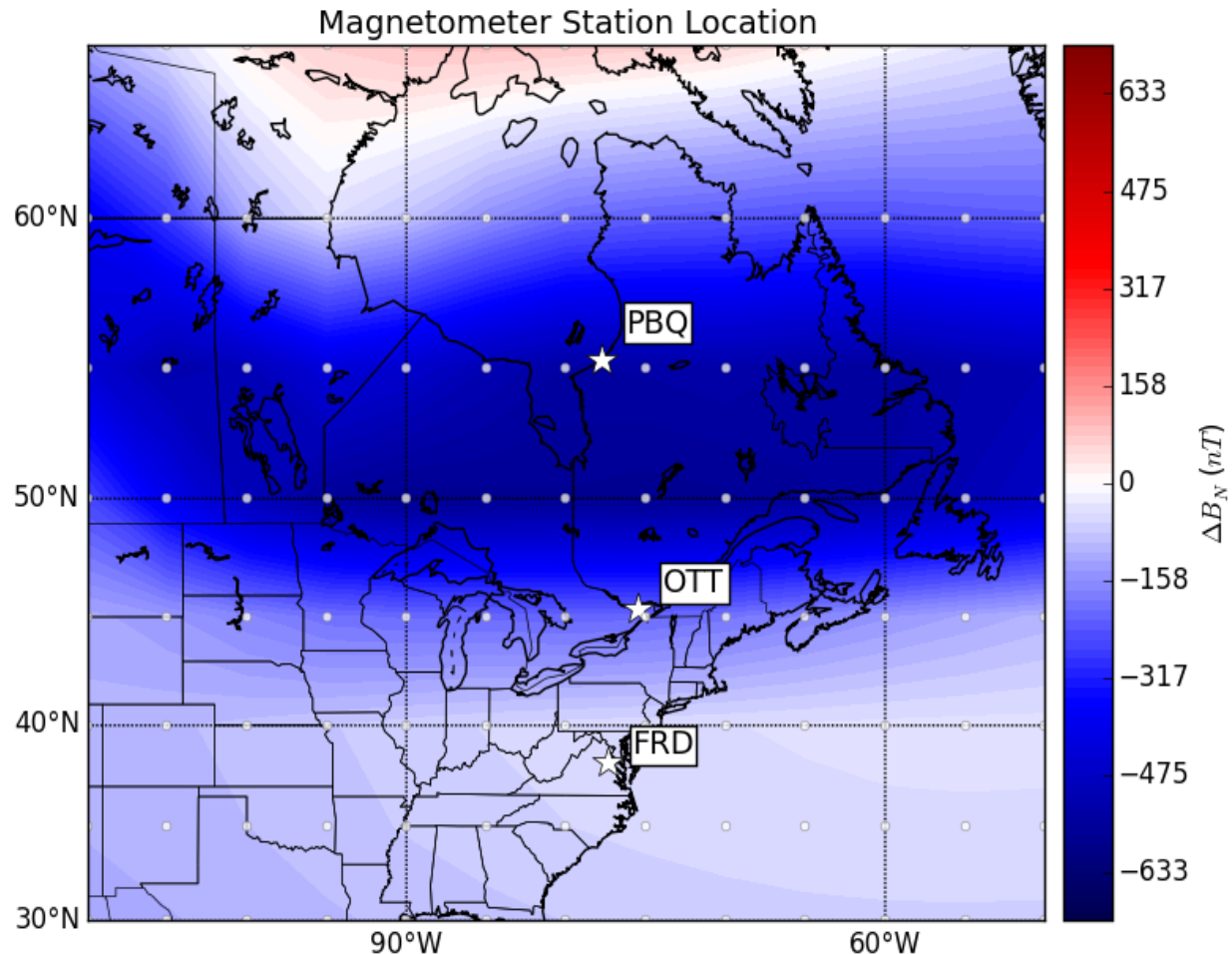
Result of SWPC/CCMC challenge was selection of SWMF for operational use.

- Model to run 24/7 on NOAA machines.
- Small NOAA/Umich contract to support SWMF R2O transition.
- 30-day test run on NCEP machines complete.

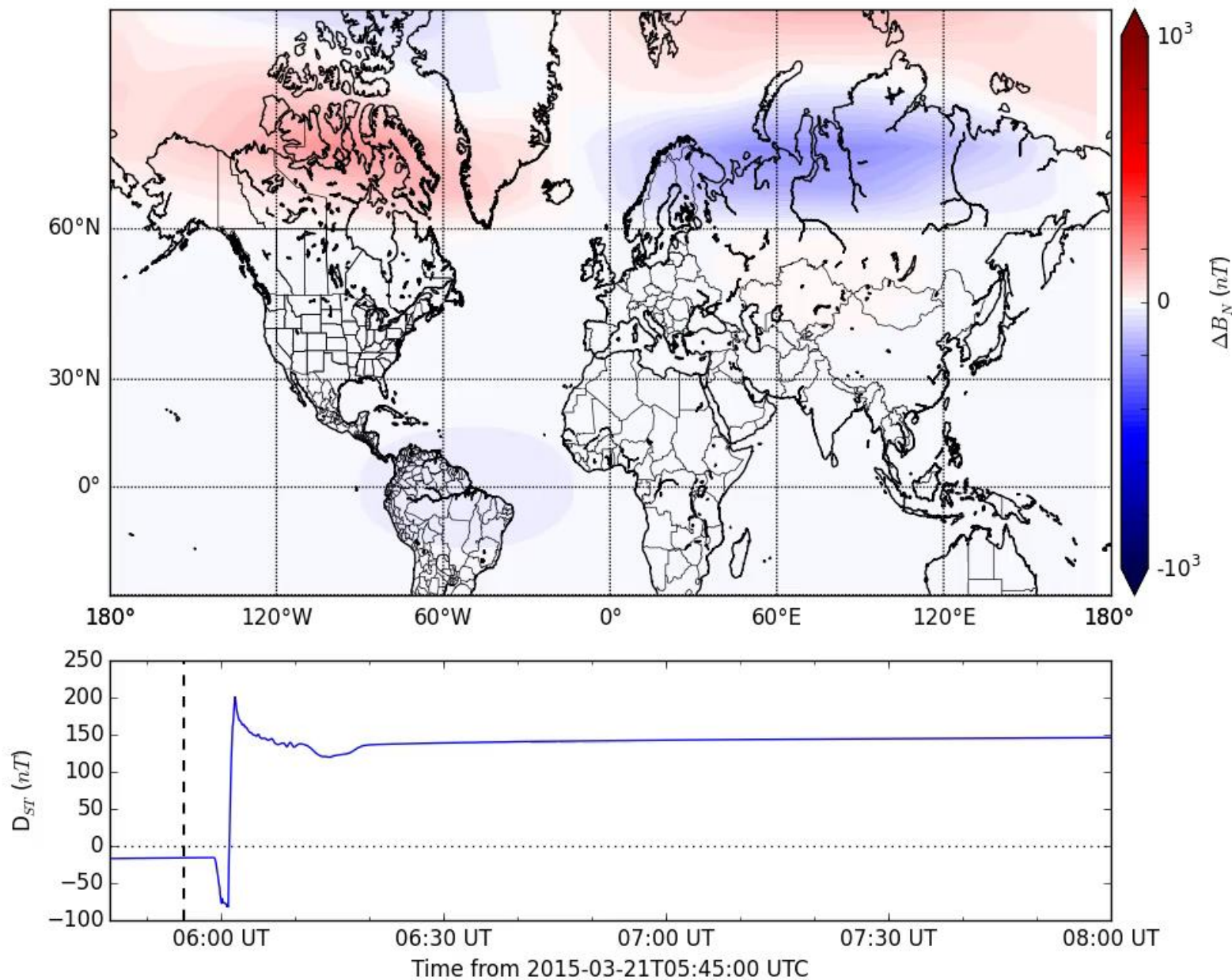


“Magnetometer Grids” enable global prediction.

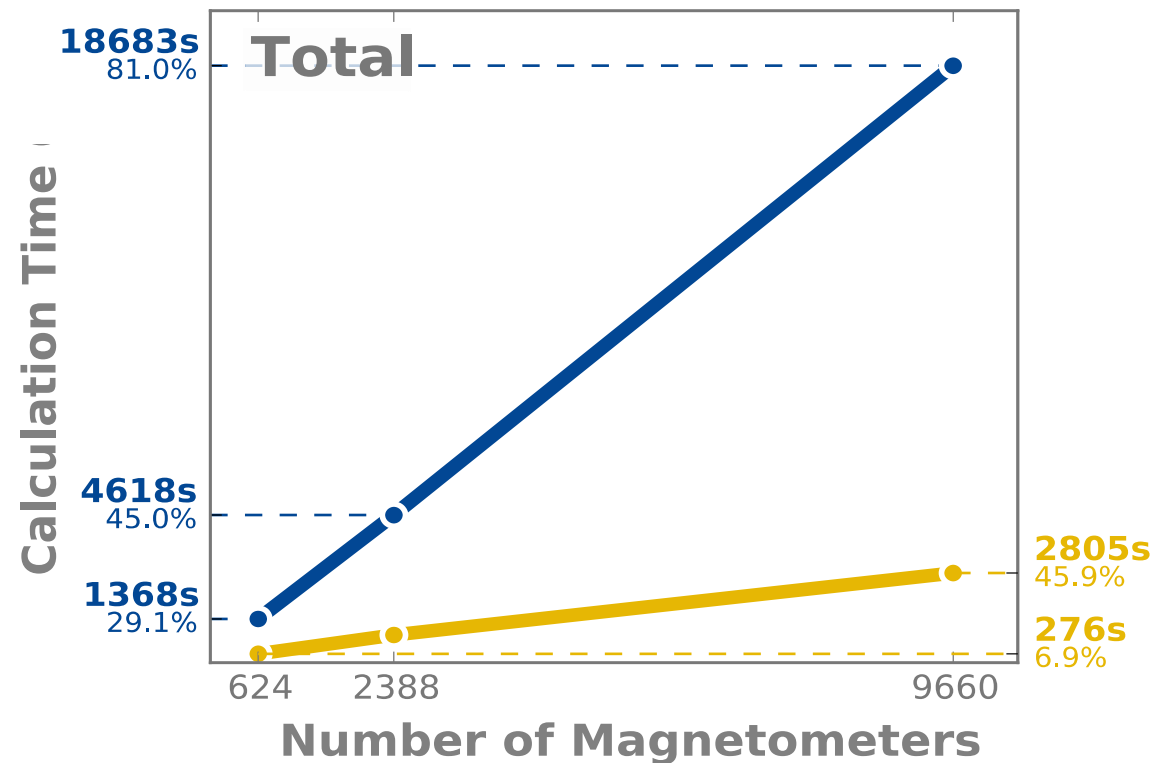
- Can interpolate results to arbitrary locations.
- $5^\circ \times 5^\circ$ separation yields accurate predictions.
- Enables *virtual indices* (K_p , AE).



Simulating Extremes



SWPC-Umich partnership enables code optimization work that is otherwise unfunded.



Old method: virtual magnetometer calculation dominated total run time.

New method: now ~25% of operational execution time.

SWPCTEST: A push-button recreation of the entire *Pulkkinen et al.* [2013] study.

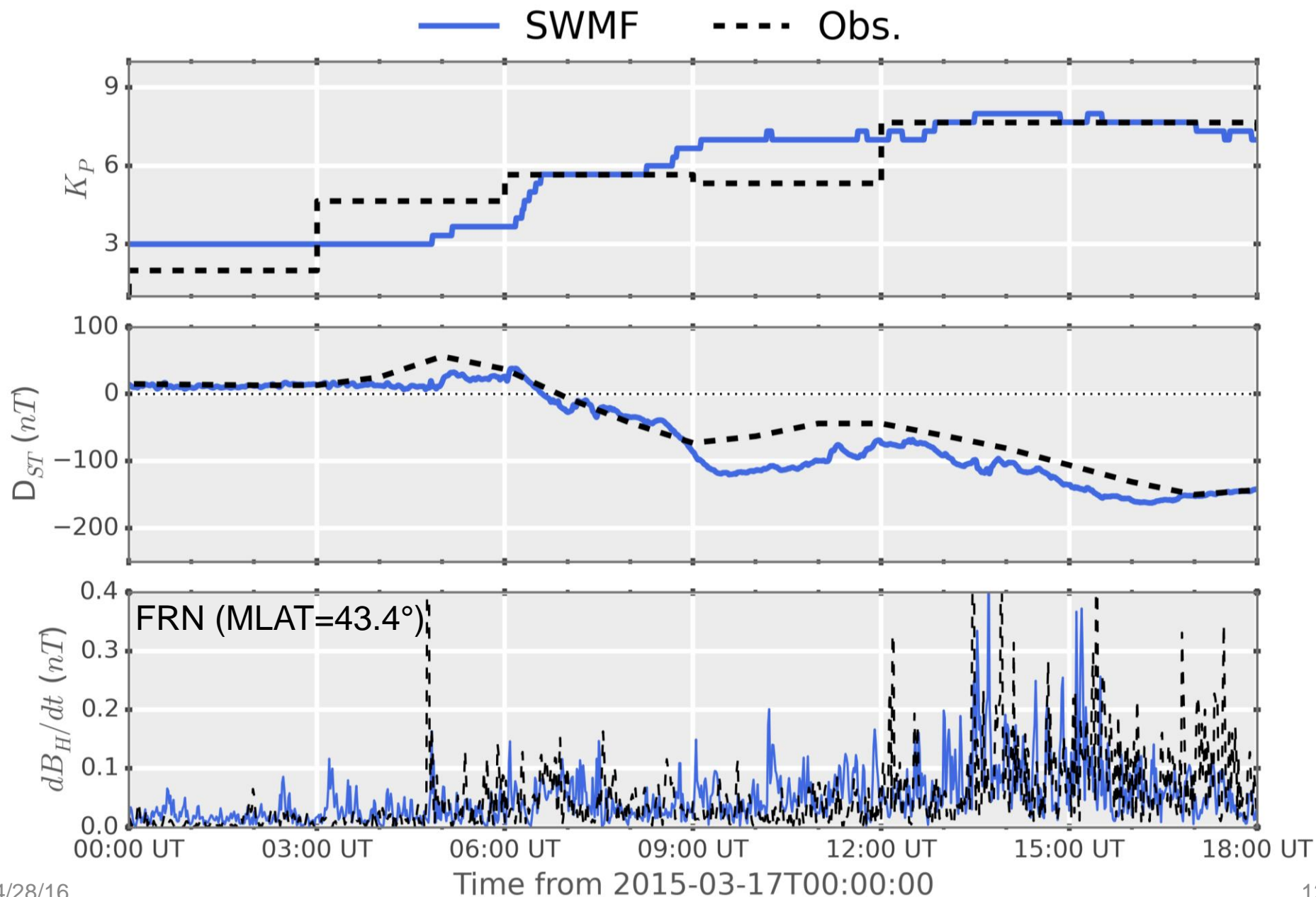
- Single command to compile & execute six-event simulation suite on supercomputer cluster.
- Produces all metrics presented in *Pulkkinen et al.* [2013] & compares to 2013 version of code

Threshold	POD	POFD	HSS
0.3 [nT/s]	0.754 (+0.061)	0.181 (+0.011)	0.517 (+0.058)
0.7 [nT/s]	0.637 (+0.073)	0.144 (+0.032)	0.500 (+0.036)
1.1 [nT/s]	0.576 (+0.080)	0.121 (+0.028)	0.476 (+0.039)
1.5 [nT/s]	0.507 (+0.094)	0.100 (+0.027)	0.434 (+0.047)

Table 1: Performance metrics for the SWMF.



St. Patrick's Day Storm



The SWMF has shown tremendous value as an operational tool.

- #1 in SWPC challenge metrics, but validation for all models is an ongoing process.
- Robust, faster-than-real-time execution.

Research-to-operations progressing well.

- Model has passed NOAA/NCEP 30-day test.

SWPC–Umich partnership has been a mutually beneficial relationship.

- Enables work that is otherwise unfunded.
- Efforts have had immediate O2R impact.